CHAPTER 4

EXTERIOR WALLS

SECTION I—CLASSIFICATION OF WALLS

4.1.1 Structural Types

Exterior walls may be classified as load-bearing walls (walls that support loads from floors, roof and equipment plus their own weight), nonload-bearing walls (walls that support only their own weight), and curtain walls (walls that have their own weight supported on structural members).

4.1.2 Material Classifications

Exterior walls fall into four general material classifications, with a wide variety of materials and applications:

4.1.2.1 *Wood and Wood Products:* Wood shingles, weatherboard siding, plywood, prefabricated panels.

4.1.2.2 *Concrete and Masonry:* Brick, concrete masonry units, reinforced concrete, precast concrete panels, structural clay tile, stone, exterior plaster (stucco).

4.1.2.3 *Metal:* Corrugated iron and steel, aluminum sheeting, precut sheet metal, enamel-coated, prefabricated steel panels, protected metals, prefabricated panels.

4.1.2.4 *Mineral and Chemical Products.* Asbestos shingles, asbestos-cement sheets (flat and corrugated), prefabricated panels (flat and corrugated), glass block and vinyl.

4.1.3 Finishes and Protective Coatings

As distinguished from exterior wall surfaces themselves, protective and decorative coatings fall into several general categories. See Tri-Services Manual, "Paints and Protective Coatings," for information regarding their application and maintenance. Exterior plaster (commonly referred to as stucco) is the application of a portland cement plaster to the exterior wall surface. Chapter 5 of this manual discusses the materials and application of interior portland cement plaster in detail. Exterior plasterwork is similar to interior plasterwork except that the exterior plaster finish coat normally contains a waterproofing agent.

4.1.4 Maintenance and Repair

Regardless of the material used in the construction and finish of exterior surfacing, it is necessary that maintenance measures appropriate to the situation be planned and carried out on a regular schedule. Where repair is made to existing types of construction and material, it is best to match the as-built specifications as nearly as possible. Improved construction techniques and materials should be constantly examined to prevent or offset similar failure. Where weathering, normal wear or other reasons dictate a requirement for repair, replacement or refinishing of an exterior wall, consideration must be given to either matching (or duplicating) existing material, replacement of the entire covering, or a completely new finish over the existing surface.

SECTION II—WOOD EXTERIORS

4.2.1 Causes of Failure

4.2.1.1 *Moisture.* The most common failure of wood and wood-products exterior siding is caused by moisture. Prolonged weathering, leaks, and cracks, which allow moisture to enter and collect behind exterior coverings, are a source of eventual problems. Condensation within and behind walls also contribute to the problems of maintenance, repair, and rehabilitation. Figure 4-1 demonstrates the mechanics which may produce damaging moisture behind paint and within walls and illustrates the use of a vapor barrier to avoid these conditions.

4.2.1.2 *Inferior Workmanship and Material.* Inferior materials used in initial construction may allow early warping and cracking, or in instances of green lumber, bleeding of sap. Painting on wet material may cause early scaling, which in turn exposes areas of the wood to severe weathering. Insufficient, loose, and displaced nailing will eventually cause problems.

4.2.1.3 *Structural Failures.* Settlement of foundations, which in turn causes displacement and misalignment of framing members, may crack, misalign and damage facing material. Occasionally, a framing member may fail under loading conditions which exceed those for which it was designed or because of inferior material. This in turn can cause displacement and damage to siding. A fact that is frequently overlooked in maintaining wood siding is that nailing or adhesion methods of fastening sheathing on the framing (studs or furring strips) provide strength to the basic structure, as well as form a covering. It follows that broken or loose siding detracts not only from weatherproofing functions and appearance, but also from the strength of the structures as well.

4.2.2 Maintenance and Repair

4.2.2.1 *Inspections.* Regularly scheduled inspection will determine the need for timely maintenance procedures. Neglect of maintenance and repair measures leads to greater and more costly problems. Painting and surface treatment must be kept in good repair. Specific structural repair and improvement methods are presented below. It is important to determine the cause of failure and correct it before surface repairs are made.

4.2.2.2 *Causes of Damage.* Siding material may be damaged by normal weathering; severe wind, snow, and ice; falling tree branches; fires; vehicle collisions; spillage of grease, fuels, and chemicals; and vandalism.

4.2.2.3 *Patching, Renailing and Resurfacing.* Make a careful check to determine that existing structural, functional and material conditions warrant repair to the existing wall rather than complete residing, insulation, or other overall repair or rehabilitation. Where existing situations are satisfactory, replace damaged material with like material. Cut out sufficient areas beyond the damaged part to obtain good jointing and sound nailing. Tighten nails in existing material to be left in place. Be sure that material receiving the new nailed pieces of sections are sound and true. (See chapter 3 for framing repair.) Cover replacement wood with finishes or paint matching the original design. When "as-built" plans are available, it is well to examine the original construction detail for assurance that out-of-vision construction and utilities will not be damaged.

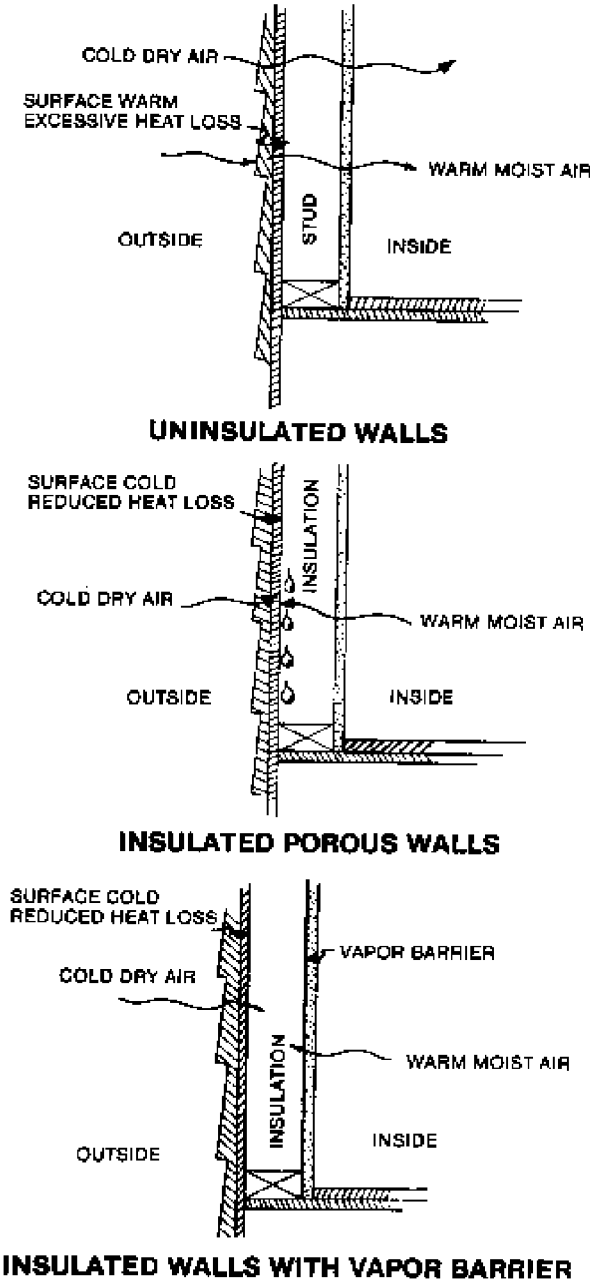


Figure 4-1. MOISTURE CONTROL IN EXTERIOR WALLS.

4.2.2.4 *Repair of Wood Shingles.* Warped, split, or curled shingles should be removed with a ripper and replaced in a similar manner to roofing shingles. See Tri-Services Manual, "Roof Maintenance" (TM 5-617, AFM 91-31, NAVFAC MO-113, and MCO P11014.9)

4.2.2.5 *Repair of Prefabricated Panels.* Panel siding will be periodically checked for looseness and faulty caulking. It is usually more economical and satisfactory to replace damaged or deteriorated panels rather than to attempt patching.

4.2.3 Residing

When existing siding does not meet functional requirements, careful consideration will be given to residing over the existing material. At this time it is

well to consider factors in connection with insulating qualities of the material to be used. If the walls are already suitably insulated within, siding or shingles may suffice. If new or additional insulating qualities are required, careful consideration should be given to the insulating factors of the new material. These considerations include whether present walls are vented or depend on porosity so vapor may reach the outer air, and what effect the addition of material may have on the existence or nonexistence of a vapor barrier within the wall, and the effectiveness of the present airspace in the wall structure. When a qualified engineer has determined what type of material is to be used, the following general rules apply for placing insulating or wood sidings.

4.2.3.1 *General.* The old wall to be recovered will be repaired to provide a sound, substantially smooth, true surface having adequate nail-holding capacity and the ability to hold the new siding firmly.

4.2.3.2 *Over Unusual Construction.* Where structures have thin level siding or similar materials applied directly to studding, which sometimes may be widely spaced, it is appropriate to fasten to the existing wall properly sized wood strips, placed at the nailing location for the new siding. These strips will serve as adequate nailing bases provided they are shimmed to true line and are properly secured.

4.2.3.3 *Over Other Material.* Where it is determined that wood siding should be on a building which has an existing surface, such as asbestos-cement or metal, which will not act as a nailing base, it is necessary to use wood nailing strips which are secured through the existing siding and into the wall studs. Otherwise, all old siding and the old sheathing may have to be removed down to the existing studding and then replaced with new sheathing as well as siding.

4.2.3.4 *Residing Over Stucco.* New siding will not be applied over old stucco. Remove the old stucco, nails, and lath, and apply new siding on existing walls.

4.2.3.5 *Other Considerations.* Whenever siding is replaced or added to existing siding, proper consideration must be given to placement of asphalt-saturated felt underlays, flashing at windows and doors, termite protection, proper surface treatments, and other items pertinent to good construction practices. These considerations will be dependent upon the existing conditions.

4.2.3.6 *Moulding, Flashing, and Caulking* When residing, the new siding may butt against or overlay the opening trim. If it overlays the trim, it should be finished by an abutting metal or wood staff moulding. If it butts against the opening trim, adequate and appropriate flashing or caulking must be used.

4.2.3.7 *Gutters and Downspouts.* New or rehabilitation work involving the repair or replacement of gutters and downspouts will be phased to insure continual drainage of roof runoff. This will prevent storm water damage to the new work or to the new siding prior to surface treatment, and will prevent water from entering uncovered wall areas.

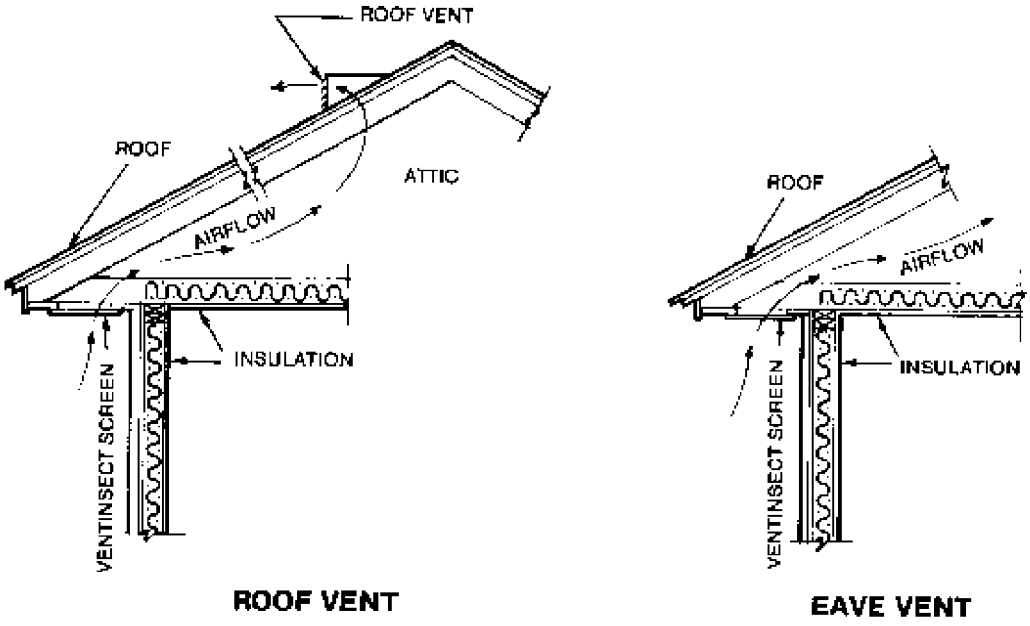
4.2.3.8 *Underlay.* On residing work where the sheathing or old wall surface is not in sound condition, an underlay of sheathing paper must be applied to prevent the infiltration of wind and moisture. Apply the underlay as the application of the siding progresses, applying only the amount of material which can be covered by the end of each day's work. Use only enough small nails or staples to hold the underlay in place until covered with siding.

4.2.4 Vapor Barriers

A vapor barrier is the best means of preventing condensation by keeping the vapor from reaching a cold surface. When existing buildings have not been provided with a vapor barrier and condensation problems exist, some relief may be obtained by use of vapor-resistant paint on interior wall faces. However, application of a vapor barrier on the inside of the warm side of the exterior wall is preferable. There are a variety of vapor barrier materials, such as impregnated paper, plastics, and metallic sheets. In most instances where a vapor barrier is to be applied within a wall, it is best to use an insulation board, batts, or similar material with an integral factory-applied vapor barrier. This accomplishes the purpose and incorporates insulation at the same time.

4.2.5 Ventilation

Venting of walls, attic, and crawl space to allow escape of vapor to the outside air will help overcome the problem of condensation. Walls may be ventilated by vents which are designed to prevent the entrance of rain or snow and are screened against insects. Vents with screens may also be placed in attic space and crawl space. Vents may be placed in loft spaces, below flat roof decks, in gable walls (louvered), in roofs (by installing insect screens at the eaves), and wall vents in crawl spaces. See figure 4-2.



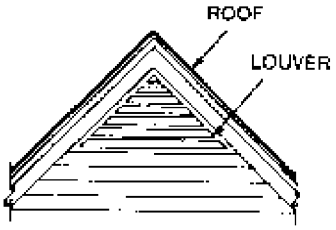


Figure 4-2. TYPICAL METHODS OF ATTIC VENTILATION.

4.2.6 Insulation

Exterior wall insulation has proved its worth many times. In maintenance of structures, questions concerning the sufficiency or deficiency of insulating qualities of walls (as well as ceilings and roofs) often arise. Some of the considerations regarding its use are discussed below.

4.2.6.1 *General.* The use of insulation varies to meet climatic conditions of the area in which a building is located, the use of the building, and the structural features of the building itself. The economic feature of saving and equalizing heat (or air-conditioning) is of primary importance. A study of the combined conditions cited above will determine the best type and method of application of insulation for a specified use. Fireproofing qualities and condensation control must be considered, as well as the insulating value of the product to be used. For consideration of double-glazing (storm sash) and weather stripping in conjunction with insulating, see chapter 7 of this manual.

4.2.6.2 *Types and Uses of insulation.* Increased insulation reduces annual energy costs and increases initial installation costs and annual maintenance costs. The greater amounts of insulation produce

unusual installation problems and increase the initial costs disproportionately to the energy saving. The optimum amount of insulation can only be determined by complete analysis of costs and savings. See appendix C, paragraph C.2.2.3. According to the DOD Construction Criteria Manual (see appendix A), buildings to be heated to 70°F 21°C) must have a factor in walls of 0.1 either in new construction or in repair renovation work.

a. Roll blankets may be used where access to the space between studs permits their use and fastening. Space must be thoroughly accessible and free of obstacles.

b. Batt blankets may be used in areas similar to those for rolled material.

c. Loose material (pellets or wool) is best suited for areas where access is through a small space. Intrawall areas between the studs and attic spaces may be poured with loose insulation material. It may also be forced in under pressure by compressed air. This form of insulation is particularly adaptable to small areas around windows and doors and in wall utility compartment vents.

d. Other types of insulation include rigid and semi-rigid composition board, which includes stiffening material, such as fiber, to make a material self-supporting. It is used most generally for perimeter insulation, such as around concrete slabs or as sheathing under the siding. Utility batts are formed from insulation, but with no envelope or vapor barrier to break the flow of air through the material. It may be used when no vapor barrier is required or where a separate vapor barrier has been provided.

4.2.6.3 *Placing Insulation.* It is most satisfactory to place roll or batt insulation between the studs of a wall while either the inside or outside surface of a building is uncovered. Thus, when resheathing the outer surface of a wall or replacing the inner surface, consideration should be given to installing insulation. When both wall faces are covered, it is necessary to pour loose insulation from the top or force it in by compressed air from some opening in the wall. In any case, care should be exercised to fill all small crevices and to pack material into confined spaces, particularly around piping and wiring. The vapor barrier side of insulation should face toward the warm side of the wall. In placing any type or kind of insulation, follow the manufacturer's instructions for proper thickness, form and fastening. Figure 4-3 illustrates application of insulating batts, blankets, and utility batts to standard wood-constructed walls. Figure 4-4 shows methods of placing insulated material on masonry and metal sidewalls.

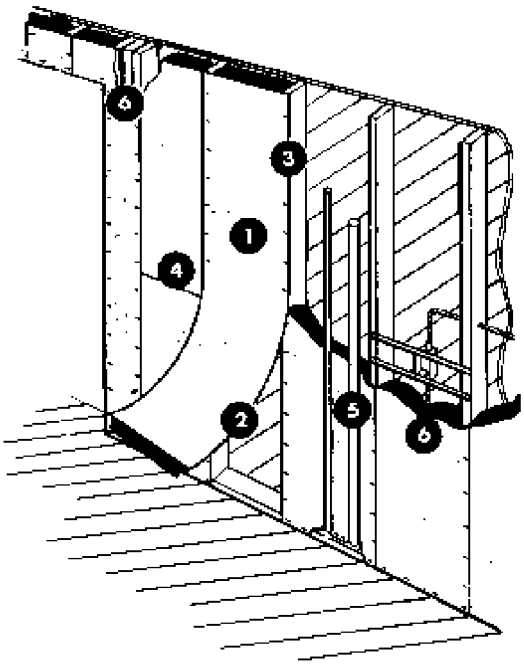
a. Batts and Blankets. In figure 4-3, the following steps are demonstrated for batts and blankets: Cut insulation to stud height plus 3 inches for top and bottom, nailing flange exposed. Start at top of stud space and work down if roll blankets are used. Batts can be installed from floor up. Staple or nail flanges to stud at 5- to 6-inch spacing. Make sure vapor barrier faces building interior. Press insulation closely together at joint so that no voids are left. Make sure vapor barrier is not broken by spaces at joints. Insulate with special care on the cold side of pipes and drains. Compress insulation behind pipes where possible or pack with utility batts or pouring wool or scraps from batts or blankets. Cut and apply vapor barrier to provide vapor protection.

b. Utility Batts. In figure 4-3 the following steps are described for utility batts: Stack 15 by 10 inch utility bats between studs. If the 15 inch dimension is placed horizontally, batts fit between studs spaced 16 inches on center. With the 15 inch dimension vertical, two batts can be packed into the space between studs on 20 inch center. Tack vapor barrier paper over the insulation to prevent condensation. For complete vapor protection, the vapor barrier must be continuous at joints. Apply roll or batt blankets to furring strips following directions given for wood sidewalls.

c. Metal Buildings. See figure 4-4. Attach furring strips to purlins or girts of the metal building on a standard spacing to tack roll blanket insulation. Staple or nail roll blankets to furring strips. Make sure vapor barrier is continuous to prevent condensation on steel sheets. Cover with desired finish.

4.2.7 Exterior Steps

Wooden exterior steps are subject to considerable weathering and mechanical abuse. Wood columns and posts supporting exterior steps and platforms should be set in concrete with wood parts no closer than 4 inches to the ground. Ease of access to these structures will make inspection simple and repair uncomplicated.



NOTE:

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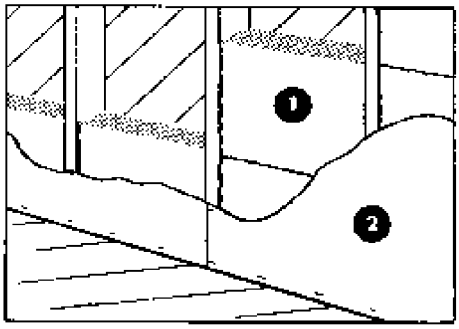
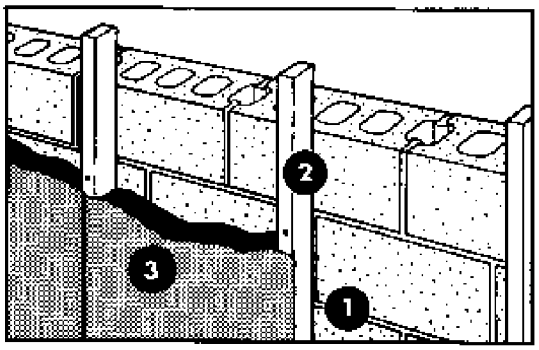


Figure 4–3. PLACING BATTS, BLANKETS AND UTILITY BATTS IN WOODFRAME WALLS.



MASONRY SIDEWALLS

NOTE:

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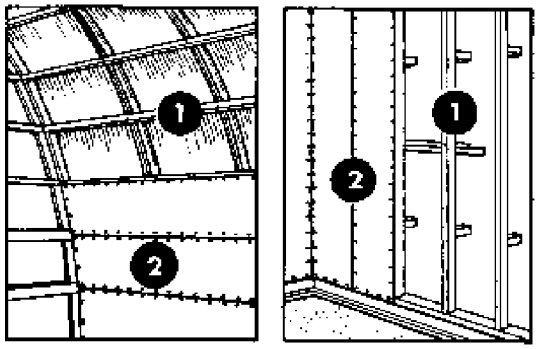

METAL SIDEWALLS

Figure 4–4. PLACING INSULATION INSIDE MASONRY AND METAL SIDEWALLS.

4.2.7.1 *Treating Porch and Walkway.* Flooring Treated lumber should be used if available. However, if it is not available, immediately upon delivery at the building site, treat all matched or square-edged flooring and planking to be used on the exterior with a preservative sealer before it is exposed to the weather. Immerse boards fully for not less than 15 minutes in a slow-drying wood sealer. After treatment, carefully stack lumber and protect it until ready to use. Before installation, dip or brush-coat all cut ends of flooring with sealer; after installation, apply a brush coat of sealer to any surfaces which have been abraded, planed, scraped, or sanded. Square-edged material laid with open joints should be used for open walkways in hospitals and other installations where open joints are not objectionable.

4.2.7.2 *Repairs.* Normally, the component members may be repaired by replacing the damaged parts in kind. Use sound material, 2 or 3 inches thick, for stringers, and space them more than 24 inches on centers. Cut stringers to form treads, using planks of sufficient width to provide at least 5 inches of uncut lumber along and parallel to the bottom edges of the stringers. Maintain uniform tread widths and riser heights throughout the run. Treads are formed of 2 x 4's or 2 x 6's or a combination of the two sizes spaced ¼ to ½ inch apart. Risers are left open. Set lower ends of the stringer on concrete footings at least 4 inches above the ground.

4.2.7.3 *Replacements.* Expected utilization of the building and extent of damage are the determining factors as to which of the following methods may be the more economical for complete replacement:

a. Replacement in kind using salvageable material supplemented with new material.

b. Concrete steps and platforms with metal pipe railings.

4.2.8 Porches

The same maintenance generally applies to porch flooring and supporting members as for framing. Treatment of material and procedures are as dis-

cussed in paragraph 4.2.7.1 above. Care will be taken to maintain porch flooring and rails in good condition.

4.2.9 Loading Platforms

Particular attention must be given to inspection and maintenance of loading platforms due to the consideration of constant application of changing live loads to the floor surface. Movement of large quantities for heavy materials, the impact of falling loads, and the constant hazard of vehicles colliding with the platform framing call for frequent inspection and maintenance. Framing is generally replaced or reinforced to match the existing structure.

4.2.10 Canopies

Repair of existing canopies or construction of new canopies will be restricted to areas and conditions as prescribed by the installation engineer. Repairs are usually made by replacing the damaged part or parts in kind. New canopies, when permitted, will be of the most economical construction consistent with the expected utilization of the building concerned.

SECTION III—CONCRETE AND MASONRY

4.3.1 General.

The frequency of maintenance for masonry and concrete exterior walls is less than that for most other exterior materials. Leakage through concrete walls is caused by cracks in the concrete and, in rare cases, porosity of the concrete. Most defects that cause appreciable problems, such as leakage, are due to the expansion and contraction of the structural members. Other common causes are settlement, excessive floor loadings, and poor workmanship in the original construction.

4.3.2 Mortar

4.3.2.1 *General.* Mortar made from good-quality material, mixed and placed under proper weather conditions and in a workmanlike manner helps produce weather-resistant, durable masonry.

4.3.2.2 *Defects and Damage.* Weathering may cause a spalling of mortar joints under the best conditions. Poor mortar mixes are usually at fault. when the face of the masonry walls is marred by stains and efflorescence. Impure water containing acids or organic matter and improper sand in the mortar mix not only cause stains through bleeding (spillage of water over a masonry surface during construction or curing), but also accelerate weathering of the mortar joints.

4.3.3 Repointing

Repointing with the best materials and skill workmanship will correct the most common fault, defective mortar joints.

4.3.3.1 *Removing Old Mortar.* Since removing mortar by hand with hammer and chisel is difficult and expensive, most masons who specialize in repointing use portable electric-driven grinding wheels to simplify the job. Cut out cracked or open mortar joints to a depth of at least ½ to ¾ inch. Remove all dust and loose material with brushes, compressed air, or water jet. If water is used, no further wetting of the joints may be needed unless the work is delayed.

4.3.3.2 *Recommended Mix.* Use mortar of about the same density as the original mortar, or use a prehydrated mortar mix in the following proportions by volume: 1 part of portland cement, 1 part of lime putty or hydrated lime, and 6 parts of sand. Prehydrate the mortar by mixing it about 2 hours before use, adding only about half the mixing water, to eliminate excessive original shrinkage and volume change.

4.3.3.3 *Application.* At the end of the 2-hour curing period, work the mortar, adding enough additional mortar to make the mixture plastic, but not enough to make it run. Be sure the joints are damp, and then apply the mortar by packing it tightly into the joints in thin layers. Tool the joints to smooth, compact, concave surfaces. If openings in the mortar are small, cutting out the joints is unnecessary, and following procedure may be used. Mix grout in proportions by volume: ½ sand, **d** portland cement, **c** limestone flour, powdered flint, or fine hydrated lime. Wet the joints, and apply two coats of grout, brushing it vigorously into the joints.

4.3.3.4 *Protection.* Protect all fresh repointing from direct exposure to hot sun and drying winds until it has set hard.

4.3.4 Efflorescence

4.3.4.1 *General.*. The source of efflorescence of walls can be found if close inspection is made when it first appears. The immediate remedy to prevent recurrence of efflorescence is to check causes of excessive moisture that contacts the wall, such as defective flashings, gutters, downspouts, copings, and mortar joints. If it appears at the edges of the

masonry unit, the mortar probably is at fault. Efflorescence at the center of the unit indicates that the masonry unit and mortar may be responsible.

4.3.4.2 *Cause of Efflorescence.* Efflorescence on masonry usually appears as a light powder or crystallization and always indicates trouble. Aside from its unsightly appearance, it is evidence that enough moisture may be penetrating the wall to cause disintegration of the masonry. The two conditions which generally produce efflorescence are the presence of water-soluble salts (in masonry units, mortar, or both) and moisture which deposits salts on the wall surface when water evaporates. This latter may be excess moisture caused by extra soaking of units before laying, or moisture taken up during storms after erection of the wall.

4.3.4.3 *Water-Soluble Salts.* Soluble salts may be present in brick, hollow tile, concrete blocks, or mortar. Tests have shown that only a small percentage (probably not more than 10 percent) of well-burned clay and sand-lime brick and hollow clay tile contributes to efflorescence. Secondhand brick, because of its uncertain origin and previous contact with mortar and plaster of unknown composition, may cause efflorescence. Concrete blocks are often made of materials containing efflorescing salts. Portland cements, limes, and sands used in mortars often contain soluble salts that cause efflorescence. The Wick Test for efflorescence, as described in ASTM C-67, is recommended for determining the presence of soluble salts in masonry units and mortar ingredients.

4.3.4.4 *Excessive Moisture.* Since moisture is necessary to carry soluble salts to exterior masonry surfaces, efflorescence is evidence that construction faults have permitted moisture to enter the wall. Excessive moisture in walls may be caused by defective flashings, gutters, downspouts, copings, or improperly filled mortar joints. Location of efflorescence does not always mean that water is entering the wall at that point. Streaks on the wall from the top down or patches some distance from the top might indicate defective gutters or copings. Patches of efflorescence are sometimes caused by opened mortar joints or projecting brick courses without enough wash (upper surface of the brick which is sloped to shed water). Water may also enter openings at windowsills and around window and door frames. Efflorescence close to the ground may indicate ground water drawn up by capillary action.

4.3.4.5 *Efflorescence Analysis.* The following checklist is helpful in determining causes of efflorescence:

a. Age of Structure. Determine the age of structure at the time the efflorescence appeared. If the structure is less than 1 year old, the source of the salts is probably the cement in the mortar, and the source of the water is usually construction water. However, if the structure is more than 2 years old, construction details should be examined for possible leaks in the wall or the adjacent construction. The sudden appearance of efflorescence on an established building previously free of efflorescence is normally attributed to a new entry of water into the construction assembly.

b. The Location of the Efflorescence. The location both on the structure and on the masonry unit or mortar joint should be carefully noted. The location of the salt crystals on the joints or the masonry units may help in determining the source of the salts. The recent use or occupancy of the building should also be noted. Has the building been vacant for some time? Has it been altered, expanded or modified?

c. The Condition of the Masonry. Careful examination of the profile of the mortar joints, the condition of the mortars, the type of workmanship, the condition of caulked joints, the condition of flashing and drips, and deterioration or eroding of mortar joints in coping or in sills should offer clues as to the entry paths of moisture into the construction.

d. Other Source of Water. If the usual sources of moisture have been eliminated, consideration should be given to other sources, such as condensation on the walls, leaking pipes, faulty drains, and condensation on heating and plumbing lines. It should be emphasized that these are rare and unusual sources of moisture for efflorescence. The principal sources of moisture should be thoroughly examined before these secondary sources are considered.

4.3.5 Types of Cracks

4.3.5.1 *Horizontal Movement.* Cracks in this category are usually long cracks in the mortar joints. They generally occur along the line of the floor or roof slab or along the line of the lintels over windows and doors, resulting from horizontal movement of the slabs involved. Where these cracks turn a corner they frequently rack down (or up) as shown in figure 4-5. Racked-down corners are discussed in paragraph 4.3.8.4 below.

4.3.5.2 *Settlement.* This usually results in diagonal cracks that reach from the lintel of one window or door to the sill of an adjacent window. These cracks generally follow the mortar joint with an

occasional break through the masonry units.

4.3.5.3 *Deflection.* Vertical and diagonal movement cracks usually occur in lintels and beams and are the result of excessive deflection, or sometimes shrinkage. See figure 4-6.

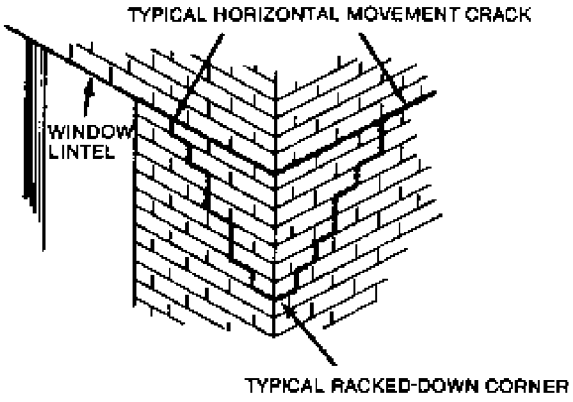

Figure 4–5. HORIZONTAL MOVEMENT AND RACKED DOWN CORNER.

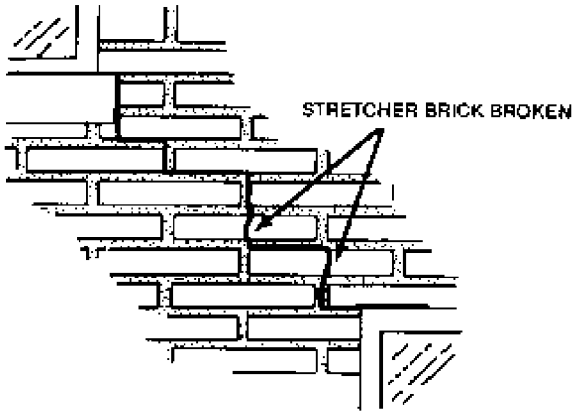

Figure 4–6. DIAGONAL MOVEMENT CRACK.

4.3.5.4 *Shrinkage.* Haphazard cracks in mortar as well as in concrete, resembling a road map, are the result of shrinkage. These cracks seldom amount to more than hairline cracks, and seldom are a cause for concern.

4.3.5.5 *Miscellaneous.* Various combinations of the cracking discussed may occur or may be combined singly or collectively with other failures, such as excessive short-term loading from the elements; external damage from vehicles or objects; failure of support through deterioration; failure attributed to uncalculated secondary stresses such as creep, vibration or impact; or progressive minor failures resulting in a major failure.

4.3.6 Repair of Cracks

4.3.6.1 *General.* Before any attempt to repair a crack is made, an engineering investigation shall be made to determine the cause of the crack. The cause should be corrected first. Repairs to cracks

in masonry have often resulted in an unsightly appearance. Cases exist where fine hairline cracks were chiseled out and repointed with mortar when such work was entirely unnecessary. In exposed walls, it is extremely difficult, if not impossible, to chisel out a joint and repoint it without producing a repaired area noticeably different from the surrounding masonry. The repaired joint in such work will be noticeable from an appreciable distance, whereas the hairline crack is barely visible. A few instances exist where the pointing mortar was left recessed below the surface of the block, thus actually defining and calling attention to the crack. Another erroneous practice in repair is to fill the crack with plastic caulking compound or a bituminous material having a color dissimilar to that of the masonry surface, resulting in an objectionable appearance. In considering the repair of cracks in concrete masonry walls, the following precautions should be observed.

a. Do not attempt to repair cracks as soon as they appear. Observe the crack periodically over a period of time to determine whether further cracking or widening of the crack will occur. Determine the cause of the crack and correct. No attempt should be made to repair cracks in a new wall, unless such action is absolutely necessary to prevent the entry of water, or for similar reasons.

b. Do not attempt to repair a fine crack by chiseling out a deep grove and repointing. Repair fine cracks by filling or bridging over with a cement-based wash or paint.

c. Do not caulk cracks above grade with light plastic or dark bituminous caulking compounds which will contrast with the wall finish. If such materials must be used, seal the caulking by coating with shellac or aluminum paint and then paint to match the surrounding area.

d. In filling joints with cement-sand mortar, size the sand to the width of the crack. Be sure to moisten the old concrete or mortar surrounding the crack to develop good bond and cure the new mortar by keeping it damp for 2 or 3 days. Do not apply waterproofing above or below grade until the pointed wall has dried (set).

e. Seal cracks below grade to prevent moisture from entering or passing through the wall.

4.3.6.2 *Determination of Method of Repair*. **If** the cracked masonry units to *be* repaired are in a wall of some prominence, where patching would be an eyesore, the cracked masonry units shall be removed and replaced. If the final appearance of the wall is of little consequence, the cracked masonry units may be patched in a manner similar to the repair described for cracks in joints, using any procedure determined feasible and economical.

4.3.7 Concrete Repairs

4.3.7.1 *Routing and Sealing.* Repair large cracks by first cutting them out to a depth of about 1 inch and a width of inch. Remove all dust and loose material with brushes or compressed air. If the cracks have been caused by initial shrinkage or expansion of the structure, fill them with mortar. If they are caused by an accepted recurrent movement of the structure, fill them with caulking material. Before applying mortar, wet the crack and adjoining surfaces thoroughly. Then neatly apply a slurry of portland cement and sand. Use 1- to 3-mix cement-sand mortar. To reduce shrinkage, prehydrate the mortar by mixing it about 2 hours before using it, adding only about half of the mixing water. At the end of the 2-hour curing period, rework the mortar and add enough water to make the mortar plastic, but not enough to make it run. Pack the mortar in the crack in fairly thin successive layers and tool it to a smooth surface, slightly in front of the adjoining surfaces. Shrinkage will be further reduced by keeping the patched portions damp for 48 hours. Caulking material should conform to Federal Specification TT-C-598. Use Grade 1 for gun application and Grade 2 for knife application. Grade 2 will shrink less than Grade 1. Before applying the caulking material, swab the cracks with a cloth moistened with turpentine or mineral spirits. *Do not use thinners in the caulking material* Do not apply primers. They usually stain the concrete and seal the pores, preventing a good bond. To place caulking compounds in cracks or expansion joints that have previously been filled with caulking, first remove the old caulking to a depth of ¾ inch.

4.3.7.2 *Repairs Using Epoxies.* The use of epoxies for bonding broken surfaces is the most successful method for sealing cracks in concrete.

a. Cracks as narrow as 0.003 inch can be sealed with epoxy compounds. Wide cracks in horizontal surfaces may often be sealed by pouring the epoxy compound into them; but in vertical surfaces and in the narrowest cracks in horizontal surfaces, applying the sealant by pressure is necessary. The usual practice is to drill holes approximately ¾ inch deep and ¾ inch in diameter into the crack from the face of the concrete at 6- to 12-inch centers and inject a solvent to flush out the defect. Valve stems or other types of entry ports are fastened in these holes with an epoxy compound. The smaller the cracks, the closer the valve stems should be placed. The surface crack

between the valve stems is sealed with a high viscosity epoxy or other compound that will contain the pressure of the injection process.

b. The injection process begins by pumping a low viscosity epoxy compound into the valve at the lowest elevation until the epoxy level reaches the adjacent valve. All valves in the circuit are then capped. The highest pressure used safely without causing relative movement between parts of the structure is applied to force the epoxy compound into hairline cracks. The pressure should approach 100 lb/in^2 if possible and should be maintained from 1 to 10 minutes or more. The pressure is then released, and more epoxy compound is pumped through the same valve until the succeeding valve is capped; the process is repeated with successive valves until the crack has been completely filled, pressurized, and all valves capped. If larger quantities of grout than anticipated are required, further investigation is necessary. Cores are often taken later to check penetration and strength.

4.3.7.3 *Chemical Grouting.* Chemical grouts consist of solutions of two or more chemicals that reset to form a gel or a solid precipitate, as opposed to cement or clay grouts that consist of suspensions of solid particles in a fluid. Cracks as narrow as 0.002 inch have been sealed in concrete with chemical grout. The advantages of chemical grout include applicability to a moisture environment, wide limits of control of gel time, and application on very fine fractures. Disadvantages are high cost, high degree of skill and expertise for satisfactory use, and shelf-life considerations and safety precautions required for successful use.

a. The ultimate goal of grouting is to place a certain grout at some predetermined location. Down-hole grout placement can be accomplished by several means. The simplest grouting situation is to pump or pour the grout directly on a surface or into an open hole or fracture. The simplest down-hole method using pressure for placement would be the use of one packer to prevent the grout from coming back up the hole while it is being pumped.

b. Selective down-hole grouting for an appreciable hole can be accomplished by placing two packers, one above and one below the area to be treated, and then injecting the grout. Another selective grout placement method is by use of "tubes a manchettes." This method entails using a tube with a smooth interior that is perforated at intervals and sealed into the grout hole. The perforations are covered by rubber sleeves,"manchettes," which act as one-way valves. Selective grout placement is obtained by a double packer arrangement that straddles the perforations. The annular grout sleeve is designed to burst under pressure which permits grout to flow into the formation.

c. A slotted or perforated pipe may be driven into a formation and then grouted, or an open-end pipe may be driven to a desired elevation and then grout. The open-end pipe can be kept open by plugging the open end with a rivet or bolt during driving. When the desired elevation is reached the pipe is raised several inches to allow the rivet or bolt to work free from the open end when pressure is applied by grouting. The pipe may also be unplugged by placing a smaller rod inside the injection pipe to total hole depth and slightly beyond.

d. Using the two-solution process, drive a perforated pipe a certain distance and inject the grout solution. This process is continued until total depth is reached and then grout solutions of the remaining chemicals are injected to complete the reaction as the pipe is extracted.

e. Selective placement of grout can be accomplished without the use of packers. This involves grouting a pipe in place, lowering a gun perforation unit that contains either shaped, charged projectiles, or a special jet charge, and firing the projectiles or jets to penetrate the pipe some distance into the formation. Either of these methods gives access to previously grouted formations and virgin formations. Elevation and direction can be dictated by this operation.

4.3.7.4 *Small Cracks in Concrete.* Repair small cracks by thoroughly wetting and then brushing cement-sand grout into them. Mix grout in proportions, by volume or equal parts of portland cement and dry sand, passing a No.50 sieve. Liquid shall be added to produce a mix suitable for brushing. Cement and sand shall be selected to produce a shade of grout that matches existing concrete. Brush the grout vigorously into the cracks. After the cracks have been filled, keep them damp for about 36 hours.

4.3.7.5 *Large Broken Areas.* Repair large broken concrete areas by cutting out enough loose concrete to expose the metal reinforcement. Remove all dust and loose materials. Wet the existing surfaces thoroughly and then cost them with a neat cement-sand slurry, as recommended for large cracks. Then apply the new concrete of a mix corresponding to that of the existing concrete. Mixing and application should conform to the applicable requirements. After the concrete is applied, keep it damp for 48 hours.

4.3.7.6 *Precast Concrete Walls.* Most precast slabs and panels are of dense, high-strength

concrete. Webs are usually thin. Repair large cracks in monolithic concrete. *Do not attempt to cut channels in precast slabs or panels.* Repair small cracks as indicated in paragraph 4.3.7.2.

4.3.7.7 *Concrete Spalling.* Repair concrete spalling using a 2-part polymeric mortar system. Remove all loose and unsound concrete by hammer and chisel. Remove small concrete pieces with a wire brush. Remove loose rust scale and all nonadherent rust from any exposed reinforcing by chipping with handtools and by wire brush. Clean all dust, oil, or other bond-inhibiting materials from patch area. Be sure depth of patch area is compatible with patching material. Before placing the patching material, thoroughly clean, dampen, and brushcoat the area to be repaired. Mix only the amount of mortar that can be used during the pot life of the specific product. Patch area with polymeric repair mortar. All surface preparation, mixing, and placing must be in strict accordance with the manufacturer's printed instructions. All work must be finished plumb, smooth, and neat to match adjacent existing areas. Protect the repair and keep it damp for the curing period specified by the manufacturer.

4.3.7.8 *Structural Concrete Patching.* Repair defective or discolored concrete with a 2-part polymeric mortar system. Remove concrete in question to a depth of no less than 1 inch. Make all cuts perpendicular to the concrete surface. Remove all loose concrete pieces with a wire brush. Before placing patching material thoroughly clean, dampen, and brushcoat the area to be repaired. Mix only the amount of mortar than can be used during the pot life of the specific product. Patch area with polymeric repair motar. All surface preparation, mixing, and placing must be in strict accordance with the manufacturer's printed instructions. All work must be finished plumb, smooth, and neat to match adjacent existing areas. Protect patch and keep it damp for the curing period.

4.3.7.9 *Grouting Bolts.* Grouting bolts into existing concrete beams, walls, and slabs using a 2-part epoxy grouting compound with an added aggregate. Remove dust, grease, standing water, and all other deleterious materials from bolthole. Remove dirt and grease from the bolt and dry it sufficiently. Mix only the amount of grout that can be used during the pot life of the specific product. Fill the bolthole to a predetermined depth with epoxy grout. Set the bolt in the hold and work it up and down, lightly tapping it to insure complete embedment. Check the bolt projection and plumbness and secure in position using a template to insure proper location. Pack or pour additional grout into the hole, if required. Allow grout to set for time period specified by manufacturer before applying load. Use a heavy liquid grout for horizontal surfaces and a gel consistency grout for vertical and overhead surfaces. All surface preparation, mixing, and application of grouting compound must be in strict accordance with the manufacturer's printed instructions.

4.3.7.10 *Bonding Toppings to Existing Concrete.* Use a 2-part epoxy concrete adhesive to bond concrete toppings to existing concrete floors. Remove all dust, laitance, oil, and other deleterious material from the existing concrete slab by sandblasting or other means of abrasive cleaning available. Remove all standing water from the area to be covered. Mix only the amount of adhesive that can be used during the pot life of the specific product. Apply the adhesive with airless sprayer, roller, brush, or squeegee evenly to the surface at the coverage specified by the manufacturer. All surface preparation, mixing, and application of the adhesive must be in strict accordance with the manufacturer's printed instructions.

4.3.7.11 *Concrete Floor Overlays.* Refinish existing concrete floor slabs using a 2-part polymeric mortar overlay. Prepare surface to be covered to the required profile of the specific product to be used. Remove all deteriorated concrete and existing toppings, dirt, oil, and other bond-inhibiting materials by sandblasting, scabbler, or other available means. Sweep or vacuum dust off entire surface. Repair all cracks in the existing slab with a low viscosity epoxy grout. Wash entire surface prior to overlay application and allow it to air dry. Apply overlay mortar to the surface and finish to the desired final surface condition. All surface preparation, mixing, placing, and finishing must be in strict accordance with the manufacturer s printed instructions. Provide joints in the overlay topping in the exact location of joints in the exiting slab. Saw-cut joints immediately after overlay has set or preform joints by inserting steel or plastic strips in the existing joints. Preformed joint strips shall not project above the top of the overlay and shall be removed after the overlay has stiffened. Tool a **c**-inch radius edge after the joint strip is removed. Protect the new overlay and keep it damp for the curing period specified by the manufacturer.

4.3.7.12 *Surface Sealants.* Protective surface coatings are used primarily to improve the durability of concrete by preventing or inhibiting the intrusion of moisture, chemicals, or waterborne salts but can also be used to lengthen the life of repair. Typical materials employed as protective surface coatings include boiled linseed oil generally mixed with

mineral or petroleum spirits or turpentine), petroleum oil, silicones, epoxy-resin coatings, asphalt materials, rubber and rubberized asphalt, or curing compounds. Epoxy coatings are the most effective under sustained exposure because they do not require replacement as frequently; but they are more expensive. Impervious coatings such as epoxy-resin coatings should never be applied to the surface of concrete slabs on grade that may be subsequently exposed to freezing unless it is certain that the concrete can resist frost action in a critically water-saturated condition.

a. Methods of Application. Sealers may be applied to old surfaces by airless spray, roller, brush, lamb's wool applicator or trowel, depending on the product. High viscosity sealers such as bituminous applications for below-grade concrete exteriors are generally applied with brush or trowel and may require reinforcing mesh to enhance resistance to tear or rupture. Some epoxy, rubber, and acrylic sealants may be applied by airless spray equipment. Most sealants may be applied by brush or lamb's wool application. The manufacturer's recommended applications should always be followed.

b. Surface Preparation. Sealants require clean surfaces for proper penetration. Surfaces should be free of existing coatings, dirt, oil, grease, or other contaminants. The type of sealant selected will determine the appropriate method for cleaning. Particular care must be taken in cleaning surfaces for application of epoxy sealants or films, which require water or sandblasting. The manufacturer will identify the appropriate cleaning methods which are detailed in paragraph 4.3.9.

4.3.8 Brick Repairs

4.3.8.1 *Mortar Preparation.* Lay new brickwork in mortar mixed in the proportions by volume of 1 part portland cement, 1 part lime paste, and 6 parts sand, or of 1 part masonry cement and 3 parts sand. Add sand so that it is distributed uniformly throughout the mass. Then add water gradually until the mortar is plastic enough for use. Portland cement and masonry cement (type II) should conform to ASTM Specification C-270. Lime paste should be made with pulverized quicklime or with hydrated lime that has been allowed to soak for at least 72 hours before use. However, hydrated lime processed by the steam method should be soaked not less than 12 hours before using it. Pulverized quicklime should conform to Military Specification MIL-L- 14519C. Ten percent should pass a No.20 sieve, and 90 percent should pass a No.50 sieve. The chemical composition and fineness of hydrated lime should conform to Federal Specification SS-L-351 and should not contain more than 8-percent free (unhydrated) calcium oxide and magnesium oxide. Lime paste, after soaking as recommended herein, should pass the plasticity test for Type F lime given in Federal Specification SS-L-351. Sand should be sharp, clean, and free from dirt, silt, organic matter, and other impurities. Mixing water should be clean freshwater and free from excess acids, alkalies, and other deleterious matter.

4.3.8.2 *Bricklaying.* Handle bricks so that their faces and edges will not be damaged. Be sure that masonry beds are clean and properly wetted. Porous soft brick should be wetted before laying in hot, dry weather to reduce the rate of absorption of water from the mortar. The amount of wetting is determined by the type of brick and the weather conditions. Glazed brick has little or no absorption; therefore, it should be laid dry. Lay the brickwork in the bond that matches the adjoining existing work. Use batts only for closures. *Completely fill all joints between bricks with mortar.* Form bed joints with a thick, smooth layer of mortar. Avoid furrows. Form cross joints by applying a full coat of mortar to the entire side or end of the brick to be laid, as the case requires, and then shove the mortar-covered end or side tightly against the bricks already in place. *Do not merely butter the corners of the brick to be laid and then attempt to fill the empty mortar joints after the brick is in place.* Form longitudinal joints as recommended for cross joints or apply a full thickness of mortar to the bricks laid previously, and then shove the next brick in place. Lay closure bricks with full-bed, longitudinal, cross joints, placing the bricks carefully without disturbing the bricks already in place. *Do not allow any dry or butt joints.* Build in metal fasteners, flashing, etc., as the work progresses. Keep joints uniform in thickness, aligning and tooling them to match joints of existing work. Remove all loose and excess mortar.

4.3.8.3 *Brick Walls.* Common defects in brick walls are open vertical joints, cracking, spalling, and porosity. Efflorescence and leakage of rainwater through the walls usually result from such defects. Inadequate or improperly designed and constructed flashings also cause serious leakage. Open, vertical joints result from failure to fill the joints with mortar in laying the brick. Cracking may result from settlement, expansion and contraction, misalignment, or some other serious structural defect in the building. Spalling results if bricks are soft or tend to powder and crack, or when moisture freezes within the masonry. Porosity in brick walls is rare and can result only from the use of porous brick or mortar. Mortar containing large aggregate or poor-quality brick may produce this porous

condition. An engineering investigation of the causes of structural defects should govern the nature and extent of major repairs. Cracked and open mortar joints should be repaired as recommended. Where masonry cracks appear at windows, doorways, offsets, and like places, an expansion joint or control joint should be provided at those locations to minimize the effect of foundation movement.

4.3.8.4 *Racked-Down Corners.* On masonry projects having concrete floor or roof slabs, buildings may have sections of masonry damaged or loosened at the corners. This occurs where the horizontal movement cracks along the side and end of a building meet. Frequently, the horizontal crack not only continues around the corner, but also forms a diagonal crack in a downward direction that meets a similar crack from the other side, forming a"V." The masonry units inside this V are loosened and must be reset. See figure 4-7. The following procedure may be used to accomplish the repair:

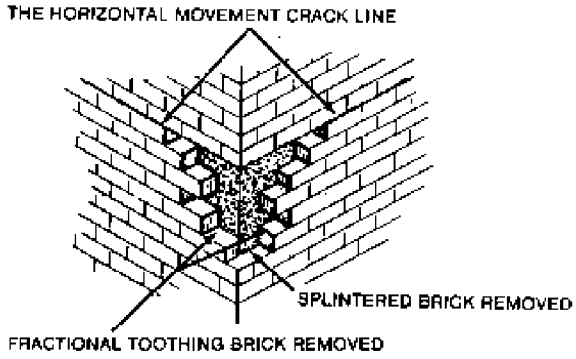

Figure 4-7. DAMAGED BRICK REMOVED.

a. Remove all the bricks inside this V, including any masonry units that have been broken. See figure 4-7. This forms regular sides and helps to hold or key the new masonry units in place.

b. After the masonry units are removed, the good masonry units should be cleaned and as many new matching ones obtained as necessary. Relay the bricks in mortar up to and even with the horizontal crack running along the side and end of the building. Making all joints the same width as the original joints matching the old mortar will result in a very presentable job. As the masonry units are relaid, the backup masonry units should be coated with mortar, so that the newly laid masonry units will be bonded to them.

c. Partially fill with mortar the top joint that is on line with the horizontal crack. This can be done by pushing the mortar into the joint with a narrow pointing trowel. When about half the depth of the joint is filled, fill the remainder with sealing compound. This system of mortaring only half a joint supports the brick above but forms a weak plane along the top of the racked-down areas. If movement occurs the mortar joint break but the relaid bricks remain in place. The sealing compound keeps the joint watertight.

4.3.8.5 *Parapet Creep.* Unequal expansion of roof slabs and masonry parapets sometimes causes parapet corners to creep. When this happens, the horizontal mortar joint at the top of the slab (or the nearest through-wall flashing) usually shears open. The corner parapet will then extend beyond the face of the wall below. If creeping continues to the point that cracks extend through the parapet and concrete spalls from the spandrel beam, and both brick and mortar begin to break off, an engineering investigation for major repairs is necessary. In most cases, approximately 20 feet of the parapet, beginning at the corner, must be removed. A new section of parapet, doweled into the wall below, is then laid. A vertical expansion joint, 1 inch wide, is provided at the juncture with the existing parapet. Through-wall metal flashing and a continuous seal of bituminous plastic cement must be provided at the bottom of and in the expansion joint. Plastic cement should conform to Federal Specification SS-C-153.

4.3.9. Cleaning Masonry and Concrete Walls

4.3.9.1 *General.* The appearance of many structures has been irreparably marred by improper cleaning methods. A cleaning method that works well on hard surfaces can be harmful to soft stone

and glazed finishes. A method that cleans marble or glazed surfaces may be entirely unsatisfactory on rough-textured surfaces. Cleaning methods safe for a masonry surface may cause damage to the mortar joints. If the surface to be cleaned has more than one kind of masonry, one cleaning method may not be safe or effective on all. The material to be cleaned and the type of stain to be removed will determine the cleaning process to be used.

4.3.9.2 *Concrete.* Many chemicals can be applied to concrete without causing injury. Chemicals having an acid reaction must be handled with caution. Even weak acids may roughen the concrete surface if left for long periods of time. Stains caused by iron, cooper, bronze, aluminum, fire, and oil are discussed below. Old long-neglected stains may require repeated treatments. Deep staining may be removed with a poultice or by the "bandage" treatment.

4.3.9.3 *Masonry.* Masonry units of low absorption and those with smooth (or glazed) surfaces generally respond readily to proper cleaning methods and resume their original appearance. Highly absorbent or rough-surfaced units are more difficult to clean. When the staining material fills the pores of the unit, attempts to remove the stain may remove part of the surface, destroy its texture, or change its appearance. The principal methods of cleaning masonry structures are with steam and water, sandblasting, and various liquids and pastes.

4.3.9.4 *Steam Cleaning.* Cleaning with high-pressure steam and water, sometimes called cold-steam cleaning, is effective and economical. It removes grime from surfaces of concrete and masonry building without harming the surfaces. After steam cleaning, masonry surfaces retain their original finish and natural color tones without the roughened surfaces and dulled edges caused by sandblasting or the dead, bleached tone caused by acid cleaning.

a. Equipment. Use proper equipment for steam cleaning. Much of it can be improvised, but the needs of an installation may make buying or renting equipment advantageous.

(1) *Steam Supply.* A continuous supply of high-pressure steam must be assured before cleaning operations begin. A truck-mounted portable boiler, together with its accessories, is generally a satisfactory source. Steam pressure for cleaning old buildings is preferably 150 lb/in^2 and never less than 140 lb/in^2. For cleaning new work 120 lb/in^2 is preferred; however, never less than 100 lb/in^2 is needed. Boiler capacity of about 12 horsepower for each cleaning nozzle is necessary. The pressure with which the steam and water mixture is driven against the wall, not volume of discharge, is important in steam cleaning.

(2) *Nozzle.* The cleaning nozzle is a most important accessory; it should be a mixing type, having a water control valve and automatic steam shutoff. One efficient type has a very narrow opening 4 inches long and can deliver an extremely fine spray at a high velocity. Operating two cleaning nozzles from each length of scaffold is good practice.

(3) *Water Supply Hose.* An ordinary garden hose is suitable for carrying water from the source to the mixing nozzle.

(4) *Steam Supply Line.* Use high-pressure steam couplings and hose, or suitable pipe and fittings, or a combination or both, to convey steam to the mixing nozzle.

(5) *Rinsing Hose.* In addition to the hose supplying water to the steam-cleaning nozzle, have another hose with ordinary garden-type nozzle and shutoff to flush the walls with water occasionally.

b. Procedure for Steam Cleaning. Cleaning is done by high-velocity projection of a finely divided spray of steam and water against the masonry surface. The mixture of steam and water spray entering minute surface depressions and openings dissolves and dislodges grime, soot, and other extraneous matter, which is later flushed down the wall by the rinsing hose. Experimentation with the cleaning equipment quickly shows the operator the best angle and distance to hold the nozzle from the wall and proper regulation of steam and wet values for most effective work. Work on one 3-foot-square space at a time. Pass the nozzle back and forth over the area; then flush with clear water before moving to the next space. Alkalines, such as sodium carbonate, sodium bicarbonate, and trisodium phosphate, are sometimes added to the cleaning water to speed the cleaning action. Although they aid cleaning, some salts are retained in the masonry and may appear on the wall later as efflorescence. To cut down the amount of salts retained, wet wall units thoroughly with clear water before beginning the cleaning operation. Immediately after cleaning, wash the wall with enough clear water to remove all possible salts from the wall face. Removal of surface dirt sometimes reveals stains. A mild acid wash may be necessary to remove them. After the stains are removed, steam the treated surface again and flush with water from the rinsing hose to remove all trace of acid wash. Steel scrapers or wire brushes may be necessary to remove hardened

deposits that cannot be removed by steam cleaning. Use scrapers sparingly and carefully to avoid damage to masonry surface. Use brushes of fine spring-steel wire to grind off the hard deposit without digging into or scratching the masonry surface. After hard deposits have been removed by scraping or wire brushing, flush off surface with water, treat it with the steam-cleaning nozzle, and flush again to remove any loose dirt which might cause future streaking or discoloration.

4.3.9.5 *Sandblast Cleaning.* Sandblasting cleans rust and scale from structural steel and many other metal surfaces efficiently. When used on masonry surfaces, it eliminates mortar smear, acid burn, efflorescence (which is inherent in acid cleaning), and chemical stains. Do not use this method on marble, terra cotta, glass, or units with glazed or other special surfaces or textures. Although it cleans effectively, it often destroys the original surface of the masonry unit. It tends to dull sharp edges (arrises), to blur ornamental detail and caring, and to roughen surfaces. Stone cleaned by sandblasting, especially limestone, appears whiter, but this whiteness is caused partly by the fact that the stone surface has been abraded.

a. Equipment Used for Sandblasting Use a ¾-inch hose if maximum air and sand pressure is required, or a 1-inch hose if volume, rather than pressure, is required. For use against brick, a pressure in the range of 60 to 120 lb/in^2 through a ¼-inch sandblast nozzle is recommended. The quality of sand needed varies with the depth of cutting to be done and the type of material to be cleaned. Fine, white urn sand, which is rounder and cuts less than sharp sand, is recommended for use on brick. Placing a canvas screen around the scaffold keeps sand from scattering and makes it possible to salvage about 75 percent of the sand. Usually, four men are required in a sandblasting crew: one attends the air compressor, one at the nozzle, and two on the ground to handle the hose, scaffold, sand, etc.

b. Procedure for Sandblasting In sandblasting, compressed air forces sand through a nozzle against the surface to be cleaned. The sand removes accumulated grime and a layer of the surface. The thickness of the layer removed depends on the type of sand used, the air pressure, the volume of sand applied, the nearness of the nozzle to the surface, and the length of time that the sand is applied to one area. Sandblasting can be used safely on hard brick by an experienced operator using caution, and on sand finish with extreme caution. The nozzle operator should experiment with his equipment on a small, secluded area to determine how far to stand from the wall, which pressure is best, and the angle at which sand will clean the surface, but not etch it. The operator should concentrate on hitting the brick surfaces, and not the mortar joints. When hardness between masonry units and mortar joints differs widely, sandblasting may cut deeply into the mortar. If this occurs, joints must be repointed. Roughened surfaces produced by sandblasting gather soot and dirt quickly; therefore, the application of a transparent waterproofing is desirable. This coating fills surface pores, tends to make the wall self-cleaning, and prevents rapid soiling of surface by smoke and dust.

4.3.10 Chemical Cleaners

4.3.10.1 *General.* Acid and caustic concentrations and space mixtures are used to clean many interior and exterior surfaces. The cleaning material used depends on the texture of the surface to be cleaned, the age of the structure, the material or stain to be removed, and the capabilities of the cleaning crew. The most satisfying results will be obtained by balancing all the above factors and observing a trial application on a sheltered area. Many burned-clay surfaces, concrete surfaces, and glazed (or polished) surfaces of tile, marble, and glass can be cleaned by hand-scrubbing with a white soap powder dissolved in soft water, using ordinary fiber scrub brushes. Rinse surfaces thoroughly with clear water after scrubbing them.

4.3.10.2 *General Precautions in Using Acids.* Do not use acid solutions to clean limestone and similar materials unless experienced operators and expert supervision are available. Acid washes tend to eat into stone surfaces and pit them. They usually bleach, producing an unnatural appearance, and may cause yellow stains to appear later. If acid solution is not thoroughly washed from the masonry pores after cleaning, the destructive action continues for some time. When mixing acid solutions, always *pour acid into water.* Handle acid solutions carefully because they are harmful to the skin and especially to the eyes. When working with acid cleaners, wear goggles, gloves, and protective clothing, and keep a supply of running water at hand. Use only wooden containers and fiber brushes when cleaning with acids. Do not use metal containers or wire brushes and steel wool to scrub the walls because small steel particles become lodged in crevices, producing rust spots and stains.

4.3.10.3 *Removing Mortar Stains.*

a. General Cleaning Procedure. Make the cleaning operation one of the last phases of the job. Do not start before the mortar is thoroughly set and

cured. Remove large particles of mortar with wooden paddles and scrapers before wetting the wall. In some cases it may be necessary to use a chisel or wire brush. Presoak the wall. Saturate the masonry with clean water and flush off all loose mortar and dirt. Protect the area below the surface being cleaned. Keep all masonry below soaked with water and flush off all acid and loose mortar. Protect ornamental shrubs and pedestrians, as required. Clean only a small area at a time (approximately 10 to 20 square feet). It may be necessary to reduce this area when heat, sunlight, warm masonry, or warm winds increase the reaction rate of the acid or accelerate drying. Rinse the wall thoroughly with plenty of clean water after scrubbing.

b. Cleaning Dark- and Light-Colored Brick with Nonacid Solution. Follow directions outlined in paragraph 4.3.10.3(1), General Cleaning Procedure. Scrub wall with a solution of ½-cup trisodium phosphate and ½-cup household detergent, dissolved in 1-gallon clean water. Use stiff fiber brush only.

c. Cleaning Dark Brick with Acid Solution. Acid cleaning should be used only in difficult cases. Follow directions outlined in paragraph 4.3.10.3(a), General Cleaning Procedure. Mix 1 part clean, stain-free commercial-grade, hydrochloric acid (muriatic) with 9 parts clean water in a nonmetallic container. *Pour acid into water; never pour water into acid.* Apply and scrub the brick with a long-handled fiber brush having no metallic parts.

d. Cleaning Light Brick with an Acid Solution. Use the same procedure as for cleaning dark brick, except mix 1 part of the highest grade acid (chemically pure) available to 15 parts clean water; then neutralize the acid immediately after cleaning. Neutralizing can be accomplished by flushing the wall with a solution of potassium hydroxide or sodium hydroxide, mixed at the rate of ½ pound of hydroxide in 1 quart of water (2 lbs/gal). Allow this solution to remain on the wall for 2 or 3 days. The white salts left on the wall by the hydroxide may be hosed off or will be removed by a heavy rain.

e. Cleaning Glazed Brick and Tile. Glazed brick and tile should be carefully wiped clean with a soft cloth within a few minutes after laying. A final cleaning with a soft sponge or brush and ample water will usually do the job. In more difficult cases, use the same procedures as used for cleaning dark- and light-colored brick with nonacid solutions, paragraph 4.3.10.3(b); do not use metal cleaning tools, brushes, or abrasive powders. A second method for cleaning is the method described for cleaning light brick with an acid solution, paragraph 4.3.10.3(d), using no more than 1 part high-grade acid (chemically pure) to 25 parts clean water. *Never use acid to clean salt-glazed or metallic-glazed masonry units.*

f. Efflorescence Stains. Follow the steps outlined *in* paragraph 4.3.10.3(a), General Cleaning Procedures. Efflorescence can frequently be removed by water applied with a stiff scrubbing brush. In those cases where the water procedure does not remove all the stain, the surface can be scrubbed with a solution of hydrochloric (muriatic) acid mixed at the rate of 1 part commercial-grade acid to 9 parts water.

g. Vanadium Stain. Green stains are usually caused by salts of vanadium and can be removed by the method for neutralizing described in paragraph 4.3.10.3(d).

4.3.10.4 *Paints and Similar Coatings.*

a. Whitewash, Calcimine, and Cold-Water Paints. To remove whitewash, calcimine, or cold-water paints, wash the surface with an acid solution of 1 part muriatic acid and 5 parts water. Scrub vigorously with a fiber brush as the solution foams. When coating has been removed, wash the wall with water from an open hose until all traces of acid are removed. If a paint film is old, crumbling, and flaking, scraping with wire brushes and metal scrapers may be necessary. While this method is effective, it may leave metal particles, which later cause rust stains in the wall surface.

b. Oil Paint, Enamels, Varnishes, Shellacs, and Glue Sizings. Remove oil paint, enamel, varnish, shellac, or glue sizing by applying a paint remover that is left on until the softened paint can be scraped off with a knife or flushed off with water. After the paint is removed, wash the wall thoroughly to remove all traces of acid. Efficient paint removers include:

(1) Commercial paint remover.

(2) Trisodium phosphate — 2 pounds to 1 gallon of hot water.

(3) Caustic soda—2½ pounds to 1 gallon hot water.

(4) Sodium hydroxide—1 part dissolved in 3 parts water and added to 1 part mineral oil. Stir mixture until emulsified; then stir in 1 part sawdust or other inert material.

(5) Soda ash and quicklime—equal parts mixed with enough water to form a thick paste. Leave this mixture on the wall for 24 hours before

scraping off. if the oil-paint is very thick and hard, this method may fail, in which case sandblasting or burning may be the best way to remove it.

4.3.10.5 *Iron Stains.* Iron stains can usually be recognized by their resemblance to iron rust or by their proximity to steel or iron members in the building. Large areas of concrete or cement stucco may be stained if curing water contains iron. This stain can generally be removed by mopping the surface with a solution of 1-pound oxalic acid dissolved in 1-gallon water. After 2 or 3 hours, rinse with clean water, scrubbing at the same time with stiff brushes or brooms. Some spots may require a second mopping and scrubbing. For older, deeper stains the following methods are recommended:

a. Method 1. Dissolve 1 part sodium citrate in 6 parts lukewarm water. Mix thoroughly with 7 parts lime-free glycerin. Add to this solution enough whiting (chalk powder) or kieselguhr to make a paste poultice stiff enough to adhere to the surface when applied with a putty knife or trowel to a thickness of ½ inch or more. Allow a minimum of 2 days for drying. Scrape off and wash thoroughly. If the stain has not disappeared, repeat the treatment. This treatment has no injurious effects, but its action may be too slow for bad stains. Ammonium citrate produces quicker results, but may injure a polished surface slightly, making a repolishing necessary.

b. Method 2. The sodium hydrosulphite combination "bandage practice" method is more satisfactory for removing deep, intense iron stains. Make a solution by dissolving 1 part sodium citrate crystals in 6 parts of water. Dip white cloth or cotton batting in this solution, place the cloth over the stain, and leave it there for 15 minutes. On horizontal surfaces, sprinkle a thin layer of hydrosulphite crystals over the stain being treated with sodium citrate, moisten with water, and cover with a paste of whiting and water. Give vertical surfaces the sodium citrate treatment. Place layer of whiting paste on plasterer's trowel, sprinkle on a layer of hydrosulphite crystals, moisten slightly, and apply to stain. Remove treatment after 1 hour. If left on longer, a black stain may develop. Wash treated surface with clean water. If inspection shows incomplete removal of the iron stain, repeat the cleaning operation, using fresh materials.

4.3.10.6 *Fire and Smoke Stains.*

a. Method 1. Fire and smoke stains can sometimes be removed by scouring with powdered pumice or a grit scrubbing powder. After removing the surface stain by scouring, the deep-seated stain can be removed by applying the trisodium-phosphate-chlorinated-lime solution. Fold a white canton flannel cloth to three or four thicknesses, and saturate with the liquid. Paste this saturated cloth over the stain, and cover with a slab of concrete or sheet of glass, making sure the cloth is pressed firmly against the stained surface. If the surface is vertical, devise a method to hold the saturated cloth firmly against the stain. Resaturate the cloth from time to time. Wash surface thoroughly at end of treatment.

b. Method 2. Make a smooth stiff paste of trichlorethylene and powdered talc and apply as a troweled-on poultice. Cover poultice with glass or pan to prevent rapid evaporation. Allow time to dry. Scrape off and wash away all traces of treatment material. Trichlorethylene gives off harmful fumes; therefore, see that closed spaces are well ventilated when using this stain remover.

4.3.10.7 *Copper and Bronze Stains.* Copper and bronze stains are usually green, but may be brown in some cases. Mix 1 part dry ammonium chloride (sal ammoniac) and 4 parts powdered talc, add water, and stir to a thick paste. Trowel ¼-inch layer of paste over the stain and leave until dry. When working on polished marble or similar fine surfaces, use a wooden paddle to scrape off dried paste. An old stain may require several applications.

4.3.10.8 *Oil Stains.* Oil penetrates most concrete readily. Oil spilled on horizontal surfaces should be immediately covered with a dry powdered material such as hydrated lime, fuller's earth, or whiting. Sweep up the powdered material, taking as much of the oil as possible. Scrub with a 10 percent acid solution (phosphoric or muriatic) containing a detergent, and wash with water. If treatment is made soon enough, there will be no stain. However, when oil has remained for some time, one of the following methods may be necessary:

a. Method 1. Mix 1 pound trisodium phosphate in 1 gallon water, and add sufficient whiting to make a stiff paste. Spread a layer of ½-inch thickness over the surface to be cleaned. Leave paste until it dries (about 24 hours), remove and wash surface with clear water.

b. Method 2. Saturate white canton flannel in a mixture of equal parts of acetone and amyl acetate and place it over the stain. Cover the cloth with a slab of dry concrete or sheet of glass. If stain is on a vertical surface, improvise means to hold cloth and covering in place. Keep the cloth saturated until the stain is removed. Covering saturated cloth with glass tends to drive the stain in, while the slab of dry concrete will draw out some of the oil.

4.3.10.9 Ink Stains.

a. Blue or Black Ink& Stains from different types of inks require different treatments. Because of their acid content, ordinary writing inks may etch concrete. To remove a stain of this type, make a strong solution of sodium perborate in hot water. Mix it with whiting to form a thick paste. Apply it in a ¼-inch layer, and leave until it is dries. if some of the blue color is visible after the poultice is removed, repeat the process. If only a brown stain remains, treat it by Method 1 recommended for iron stains. Sodium perborate may be obtained from any druggist. Some blue inks contain Prussian blue, a ferrocyanide of iron. These stains cannot be removed by the perborate poultice, Javel water, or chlorinated lime poultice. They yield to treatment by ammonia water applied on a layer of cotton batting. A strong soap solution applied in the same way may also be effective in some cases.

b. Bright-Colored Inks. Many red, green, violet, and other bright-colored inks are water solutions of synthetic dyes. Stains made by this type of ink can usually be removed by the sodium perborate poultice that is recommended for ordinary writing ink stains. Often the stain can be removed by applying ammonia water on cotton batting. Javel water, conforming to Federal Specification 0-S-602, may be used in the same way as ammonia water, or mixed to a paste with whiting and applied as a poultice. A mixture of equal parts of chlorinated lime and whiting reduced to a paste with water can also be used effectively as a poulticing material. Use a chlorinated lime conforming to the requirements of Federal Specification 0-C-114 for Type II, Grade A chlorinated lime.

c. Indelible Inks. Many indelible inks consist entirely of synthetic dyes. Stains may be treated as recommended for that type; however, some indelible inks contain silver salts, which cause a black stain. This stain can be removed with ammonia water applied by bandage. Several applications are usually necessary.

4.3.10.10 *Tobacco Stains.* The following method is usually effective in removing tobacco stains. Dissolve 2 pounds of trisodium phosphate crystals, conforming to Federal Specification O-S-642, in 1 gallon of hot water. In a shallow, enameled pan, mix 12 ounces of chlorinated lime, with enough water to make a paste. Add the water slowly and mash the lumps as they form. Pour this mixture and the trisodium phosphate solution into a 2-gallon stoneware jar, and add water until the jar is full. Stir well, cover the jar, and allow the lime to settle. Add some of the liquid to powdered talc until a thick paste is obtained. Apply it with a trowel as a ¼-inch poultice. To apply the paste with a brush, add about a teaspoon of sugar to each pound of powdered talc. When it is dry, scrape it off with a wooden paddle or trowel. This mixture is a strong bleaching agent and is corrosive to metals. Care should be taken not to drop it on colored fabrics or metal fixtures. If the stain is comparatively light, use a scrubbing powder as a poulticing material. Stir the powder into hot water until a mortar consistency is obtained. Mix it thoroughly, and then apply the mixture to the stained surface in a ½-inch layer. Permit it to dry. In most cases, make two or more applications, if necessary.

4.3.10.11 *Urine stains.* To remove urine stains, use the method recommended for tobacco stains. If the stains remain, saturate cotton batting in the liquids recommended, and paste it over the remaining stains. Resaturate the cotton, if necessary.

4.3.10.12 *Rotten Wood Stains.* Damp rotten wood will produce a chocolate-colored stain that is readily distinguished from most other stains. The treatment recommended for fire stains is best. Removal of the stain will be accelerated if the surface is first scrubbed thoroughly with glycerin diluted with four times its volume of water.

4.3.10.13 *Coffee Stains.* Coffee stains can be removed by applying a cloth saturated in glycerin that is diluted with four times its volume of water. Javel water of the solution used on fire stains is also effective.

4.3.10.14 *Iodine Stains.* Iodine stains gradually disappear; however, they may be removed quickly by applying alcohol and covering the spot with whiting or powdered talc. If the stain is on a vertical wall, it may be removed by applying some alcohol to the stain and covering it with a paste of talcum and alcohol.

4.3.10.15 *Perspiration Stains.* Secretions from the hands or oil from the hair may produce stains on concrete. The stain is brown or yellow and may be mistaken for an iron stain. The best treatment is the one recommended for fire stains. Deep stains may require several treatments.

4.3.11 Glass-Block Masonry

4.3.11.1 *General.* Glass-block panels require little maintenance other than occasional cleaning and periodic inspection of joints. Theglass-block panels can be seriously damaged by superimposed loads transmitted through excessive deflections in beams and lintels, differential settlement of foundations, or by impact. The cause of serious damage must be investigated and corrected prior to making repairs.

4.3.11.2 *Materials.* The following materials are used in glass-block masonry:

a. Glass block is a hollow, partly evacuated block constructed of translucent, pressed glass, which is formed of two halves fused together at a high temperature. The exposed faces are a nominal 6-inch (5¾ inches), 8-inch (7¾ inches) and 12-inch (11¾ inches) square with a nominal 4-inch (3 **f** inches) thickness.

b. Mortar should conform to N-type mortar as described in ASTM C-270. A waterproofing mixture approved by the glass-block manufacturer may be used with the mortar.

c. Oakum shall be a nonstaining type treated to prevent mildew and dry rot.

d. Premolded expansion strips shall be of **d**-inch-thick fibrous glass material or other material recommended by the glass-block manufacturer.

e. Joint reinforcement shall be fabricated of galvanized wire consisting of two 9-gauge parallel wires spaced 2 inches on centers with a 14-gauge cross wire welded at not more than 8 inches on centers.

f. Wall anchors shall be perforated (hot-dip galvanized after perforation), 20-gauge, steel strips.

g. Asphalt emulsion shall be the type and manufacture recommended by the glass-block manufacturer.

4.3.11.3 *Installation of Glass Blocks.*

a. General. Good workmanship is essential to obtain watertight glass-block panels. Manufacturer's instructions and recommendations should be carefully studied. Minor deviations are permissible but should be for a good, valid reason.

b. Procedure. The sill area to be covered with mortar shall receive a heavy coating of asphalt emulsion not less than $^{1}/_{16}$ inch thick. When the emulsion coating is thoroughly dry, place a full mortar-bed joint. Do not furrow the mortar bed. Place the expansion strip in the jamb and head using asphalt emulsion as an adhesive. Set the first course of block. All joints must be full and not furrowed. Do not use steel tools to tap blocks into position. Blocks shall be laid in a regular straight-line pattern with vertical and horizontal joints continuous. Horizontal joint reinforcing shall be installed where indicated, or in accordance with the following General. rule:

— For blocks 6 inches square, one tie every fourth course.

— For blocks 8 inches square, one tie every third course.

— For blocks 12 inches square, one tie every second course.

Reinforcing ties shall be spaced so as not to occur in the top joint of panels. Place the lower half of the mortar-bed joint. Press the reinforcing tie into place. Cover the panel reinforcing with the upper half of the mortar bed and trowel smooth. Panel reinforcing must run from end to end of the panel. Endlaps shall not be less than 6 inches. Reinforcing must not bridge expansion joint. Wall anchors for anchoring the glass block to the masonry or concrete construction shall be spaced not more than 2 feet on centers, vertically. Panels up to 2 feet high may have a single anchor in each jamb. All panels more than 2 feet high shall have at least two anchors in each jamb. Anchors shall be crimped at jambs to provide for expansion and contraction. Anchors shall extend not less than 10 inches into the structural jamb and 1 foot into the glass-block joint and shall be completely bedded in the center of the mortar joint. While mortar is still plastic, joint shall be raked back a sufficient depth to expose the edges of the block as sharp, clear lines. While mortar is still plastic and before final set, the joints shall be tooled slightly concave and smooth. The recess left between the face of the glass-block panel and the structural jamb (or head openings) shall be rammed full with oakum to within **e** inch of the exposed surface of the glass block. The recess grooves left in front of the oakum shall be fully caulked on both interior and exterior to provide a watertight and weatherproof joint. Rake out other spaces requiring caulking to a depth equal to the width of the space. Remove surplus mortar from the faces of the glass block and wipe dry.

4.3.11.4 *Repair of Glass-Block Masonry.* Glass-block masonry panels require little maintenance other than occasional cleaning and periodic inspection of joints, except when damaged. The causes of damage must be corrected before repairs are made. To repair panels, use the following methods:

a. Remove cracked and broken glass blocks.

b. Chip off fragments of broken glass adhering to undamaged blocks, taking care not to damage wall ties and anchors.

c. Clean old mortar from exposed wall tiles and anchors and from mortar-bearing edges of adjoining blocks.

d. Replace panels using materials and methods that match existing work as closely as possible.

Mortar will be proportioned with 1 part portland cement and 1 part lime putty and 4 parts sand. Two parts mortar cement may be substituted for portland cement and lime. Mix the mortar to stiff but workable consistency. Mortar for glass block masonry should be drier than for brick masonry.

SECTION IV—METAL SIDING

4.4.1 General

The type of material used for metal siding may vary; but, generally speaking, each type requires similar maintenance and repair measures. Under conditions of foundation settlement, heavy wind and snow loading, heavy falling objects, and collision by vehicles, it is possible for metal buildings to sag, lean, or become damaged. In the event of settlement and subsequent misalignment of structural members and displacement or bending of siding, it is necessary to correct the basic problems as outlined in Chapter 2 of this manual. Where severe wind conditions or vibrations affect the stability of metal siding, it may be necessary to place additional bracing and fasteners. This should be done as directed by a structural engineer or as outlined in the siding manufacturer's instructions on sheeting and fasteners.

4.4.2 Routine Maintenance

Measures must be taken to keep all bolts, clips, rivets, nails, and other ties and fasteners tight and in place. Where corrosion has destroyed the effectiveness of a fastener, treat or replace it immediately. Where stresses may have damaged the siding connection with the fastener, patch as necessary with matching material and replace the connector to assure a positive connection. Use stainless steel or aluminum nails and neoprene washers to assure trouble-free service. They not only waterproof the joint, but also prevent corrosion. It is often advantageous from the standpoint of maintenance to use double-headed nails in placing corrugated metal siding. Where sections of metal siding have been bent badly or cut, remove and straighten the section, making neat and workmanlike patches where expedient. Where damage is severe, replace the panel with a matching substitute. Buildings that are subject to damage from vehicles should be provided with bumper guards to prevent vehicles or forklifts from striking the siding. Where metal buildings have interior insulation, take care not to damage existing construction and utilities when repairing or replacing metal wall coverings. Keep ventilators in metal buildings clean and clear of obstruction. Keep door-sliding devices and locks in adjustment and tightly fastened.

4.4.3 Steel Siding

4.4.3.1 *General.* Steel siding with protective coatings is designed to give reasonably long service. Damage from abrasion may expose the steel core to corrosion or reduce the thickness of protective coatings. Unless the damaged areas are repaired, touched up, or recoated as necessary, serious damage may result. If structural changes to a building make it necessary to cut existing steel siding, treat the affected areas to prevent corrosion. Protected steel siding is of the standard corrugated (or deep corrugation types) with the steel core protected at the factory with coatings or a combination of coverings and coatings. See figure 4-8. The sheets are resistant to flame spread. The surface is weather resistant, water repellent, and resistant to fumes, chemicals, and corrosion. The color coats are stable to heat and light and resistant to chalking. Siding sheets are furnished, complete with all flashings, fastenings, and accessories. Interior and exterior surfaces of the sheets are provided with a bituminous (black) or colored synthetic-resin, factory-applied weather surfacing. Protective coverings or coatings are applied by one of the following methods.

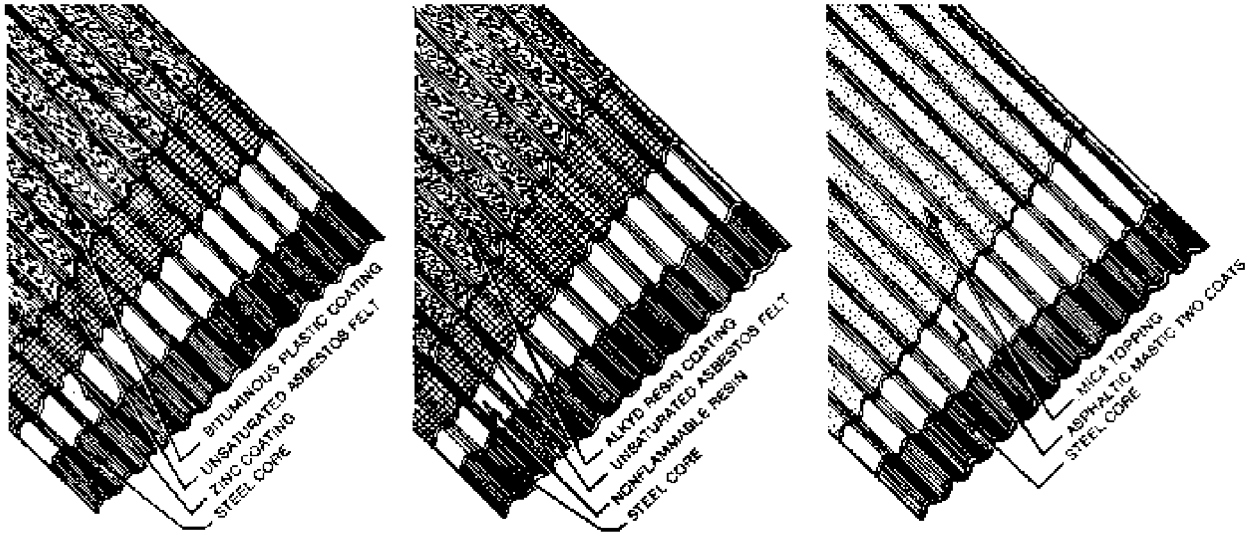

Figure 4-8. TYPES OF PROTECTED METAL.

a. Type A (felt protected, zinc-adhesive). The cleaned steel core is dipped in a bath of molten zinc, fusing the zinc to the steel. While the zinc is in a molten state, a layer of unsaturated felt is pressed over it, on each side of the sheet, squeezing the felt fibers into the zinc. The exterior or interior surface is finished with a heavy bituminous compound or a color coating of synthetic resin.

b. Type B (felt protected, plastic-adhesive). The cleaned steel core is given a phosphatising treatment, coated with a rust inhibitive primer, and a resinous adhesive. A layer of impregnated felt is rolled onto both sides of the sheet with the application of heat and pressure. The sheet is then given a protective coating of bituminous compound or alkyd-resin color compound.

c. Type C (Asphalt-protected, mineral-coated). The cleaned steel core is coated on all surfaces with a rust-inhibitive coating. The sheet is then heated and coated with adhesive. After the coated sheet has been cured, two separate coats of bituminous compound are applied. After application of the second coat, a layer of mineral mica is applied to both sides of the sheet by heat and pressure. A synthetic-resin color coating may be applied over the bituminous-compound coatings.

4.4.3.2 *Cleaning of Steel Siding.* Before repairing, touching up, or recoating, clean the affected areas. Remove all flaked coating and rust with a stiff fiber brush. Remove dust, chemical deposits, grease, and dirt. Scrape off thick deposits of grease with a trowel, putty knife, or wooden spade before using the detergent cleaner. Remove rust with a wire brush. The coatings for protected steel are petroleum asphalt compounds. They can be softened or dissolved by organic cleaners and solvents. *Do not use naphtha, bensol, xylol, gasoline, or carbon tetrachloride for cleaning protected steel.* If asbestos felt is encountered, refer to paragraph 4.5.3.

4.4.3.3 *Repair of Steel Siding.* To insure compatibility, recoating compounds conforming to the manufacturer's specification should be used in recoating protected steel. Recoating procedure is as follows:

a. Type A and B Materials. For small areas (under 10 square inches) of steel core exposed, coat the exposed steel, including a width of about 1 inch of the adjoining asbestos felt- and bituminous-covered surfaces, with asphalt primer. Allow the primer to dry for at least 24 hours and then apply bituminous plastic cement. Build up the plastic cement to form a continuous plane with

adjoining surfaces. When the cement has been exposed to the weather for at least 24 hours, apply a coat of bituminous compound. Thin the compound to brushing consistency with a suitable solvent and apply it at the rate of about 1 gallon to 125 square feet. Overlap adjoining area about 1 inch. For large areas (10 square inches or more) of steel core exposed, prime the metal surfaces and about 1 inch of the adjoining areas as recommended for small areas. Then apply a brush coat of bituminous compound, using about 1 gallon for each 75 square feet. While the compound is still wet, apply 48- by 48-mesh, unbleached muslin weighing 4 ounces per linear yard, or a porous, tough mat of fiberglass reinforced with random continuous glass yarns and bonded with a resinous binder compatible with bituminous coatings. Before using muslin, soak it in clean water until all sizing has been removed, and hang it up until it is damp dry. Apply the damp muslin or the fibrous glass mat firmly and evenly into the bituminous compound. Provide a continuous pleat in the muslin in the center of and parallel with each low corrugation of the protected metal roofing and siding. At side or end laps, pleat the muslin or the glass at the edges of the overlapping sheets of protected steel and tuck the muslin or glass into the crevice between the sheets. Immediately after the muslin or glass is installed, apply a brush coat of the bituminous compound recommended for the first coat. Cover the muslin or glass completely. Allow this coat to dry for at least 24 hours. Then apply a final coat of the bituminous compound at the rate of 1 gallon for each 75 square feet over the repaired area.

b. *Type C Material.* For small areas (under 10 square inches) of steel core exposed follow the treatment recommended for Type A and B materials, except that the final coat should be of asphalt-base emulsion. While the coating is still tacky, cover it completely with 160-mesh mica topping. For large areas (10 square inches or more) of steel core exposed, prime the steel surface, including a width of about 1 inch of the adjoining bituminous covering, as recommended for smaller areas. Then apply a brush coat of asphalt-base emulsion at the rate of 1 gallon for each 75 square feet. While the emulsion is still wet, apply muslin or fibrous glass mat as recommended for Type A and B materials. Immediately after the muslin or fibrous glass is installed, apply a brush coat of the asphalt emulsion, covering the muslin or fibrous glass completely. Allow the emulsion to dry for at least 24 hours. Then apply a final coat of the emulsion at the rate of 1 gallon for each 75 square feet. While this coat is still tacky, apply an overall coat of 160-mesh mica topping.

4.4.3.4 *Rusted and Loosened Fasteners.* Replace corrosion-weakened bolts and screws with new bolts or screws. If the old holes are too large for the new fasteners, drill new holes in an adjoining solid portion of the sheet. Use stainless-steel, sheet-metal screws for fastening sheets to each other, and use stainless-steel self-tapping screws to fasten sheets to structural steel. Clean the rust from old holes, cover them with muslin or fibrous glass patches, and recoat them as recommended for repairing large areas of exposed metal core.

4.4.3.5 *Caulking Side and End Laps.* If water is entering the building through the laps, caulking of the laps is usually necessary. Before caulking, however, be certain that all fasteners in the vicinity of the leaks are tight. Remove all dirt and debris from the laps. Using a caulking gun, lay a continuous bead of plastic cement along the edge of the protected steel siding. Then force the cement into the lap with a putty knife or a small pointed trowel. After the cement has been worked into the lap, smooth off the exposed cement and remove any excess cement.

4.4.3.6 *Painting.* Recoat or paint protected metal if the existing coatings are dry and brittle and recoating or painting will extend the life of the protected metal for several years. Recoating or painting should be done during warm weather. It should not be done while it is raining or when the surfaces are wet. Be sure the surfaces are clean. Type C material cannot be painted or recoated unless the surface mica is removed or has disappeared. Refer to Tri-Services Manual, "Paint and Protective Coatings" (TM 5-618, NAVFAC MO-110, AFM 85-3).

4.4.3.7 *Unpainted Surfaces.* If the existing surfaces have not been painted, coat them with bituminous compound conforming to DOD Specification DOD-C-2687B. Before applying the compound to dry and brittle surfaces, apply a coat of asphalt primer conforming to Federal Specification SS-A- 701. Allow the primer to dry for at least 24 hours. Thin the bituminous compound to brushing consistency with a suitable solvent. Use 4-inch paint brushes with coarse, stiff bristles to apply the coating.

4.4.3.8 *Painted Surfaces.* If the existing protected steel siding has been previously painted with aluminum paint that has deteriorated or flaked off, repaint it with aluminum paint. Be sure to remove all loose and blistered paint before repainting. For repainting, use aluminum paint mixed in the proportions of 2 pounds of aluminum paste-pigment, Type II, Class B, to 1 gallon of Type 1, Class B, mixing varnish for aluminum paint. Apply the paint

at the rate of about 1 gallon to 140 square feet. Best results are obtained by spray applications rather than brushing. The use of brushes may cause bleeding of the bituminous coating underneath. If local conditions make brushing rather than spraying necessary, use a 3- or 4-inch, soft long-bristled brush. Lay the paint on the surface, working in one direction only. Work rapidly, do as little brushing as possible,.and do not brush the paint into the surface. Follow the applicable portions of the Tri-Services Manual, "Paint and Protective Coatings," in applying the paint. Be sure that all areas are covered. Aluminum paint has a tendency to "leaf" immediately after it has been applied. Touching up an insufficiently painted area usually results in a spotty job.

4.4.4 Aluminum Siding

4.4.4.1 *General.* Aluminum siding material coated with factory-laminated, polyvinyl-fluoride film is available as a protected metal siding. Aluminum unbacked lap siding 0.024 inch thick is bonded at the factory with a laminated, polyvinyl-fluoride film finish not less than 1.5 mils thick on the face side. The back coating is a factory-applied, corrosion-inhibiting coating.

4.4.4.2 *Cleaning of Aluminum Siding.* Before repairing, touching up, or recoating, clean affected areas. Remove all loose or torn asbestos felt, flaked coating, and rust with a stiff fiber brush. Remove dust, chemical deposits, grease, and dirt. Use synthetic detergent cleaner to remove chemical deposits and grease. Thick deposits of grease can be scraped off before using cleaner. The coatings of most protected metal are petroleum asphalt compounds that can be softened or dissolved by organic cleaners and solvents. Do not use naptha, benzol, oxylol, gasoline, or carbon tetrachloride for cleaning protected metal. For further information on cleaning aluminum surfaces, refer to the Tri-Services Manual, "Paint and Protective Coatings."

4.4.4.3 *Repair of Aluminum Siding.* Minor repairs to the polyvinyl surface can be made with an enamel paint recommended by the siding manufacturer. Extensively damaged siding should be replaced.

SECTION V — MINERAL AND CHEMICAL PRODUCTS

4.5.1 General

Developments in combining chemical and mineral elements have produced hard-surfaced, weather-resistant materials for exterior wall finishes. These materials require little maintenance except to keep fasteners secure and to remove stains acquired from other sources. According to manufacturer's instructions, painting could be accomplished; however, military regulations prohibit doing it unless exception to policy is obtained.

4.5.2 Asbestos-Cement Siding

Asbestos fibers have been found to be injurious to health when breathed under certain conditions. As a result, some products such as asbestos fiber insulation and asbestos cement shingle siding have been removed from the market and laws exist restricting their usage. Although these high visibility products have been discontinued, asbestos and asbestos products continue to be manufactured and sold under their trade names. Usage of these products is considered perfectly safe provided some caution is exerted, particularly with disposal. Any operation such as sawing, cutting, or pulverizing, which might create dust, should be avoided. Limited cutting may be done when the operator wears a dust mask and disposes of the residue without permitting it to become windborne. Since many military installations have large numbers of buildings covered with asbestos-cement shingles which must be retained, the following paragraphs pertaining to its handling are contained in this manual. At such time that the appearance and usage makes replacement advisable, new siding of aluminum, steel, or vinyl with insulation should be installed as outlined in appendix C.

4.5.3

Asbestos containing materials are found in varying degrees and locations in structures built through 1979. With the passing of the Clear Air Act, the use of sprayed on asbestos-containing friable materials was banned in new construction. Much non-friable and encapsulated materials continued to be used and still remain in place with little hazard.

Asbestos-cement, for example, was used in the manufacture of water pipe and roof and siding products. The laws pertaining to the repair, removal and disposal of asbestos-cement and other ACM continue to change. Operation and Maintenance personnel are referred to Service manuals, regulations or other guidance on asbestos control and abatement and to publications of the Environmental Protection Agency, the Occupational Health and Safety and Administration and applicable State and local agencies.

4.5.4 Translucent Structural Panels

Siding produced from combining polyester resins, fiberglass, and plastics may be encountered in some new construction. As is the case with other flat and corrugated sidings, it is important to keep fastening devices tight and replace broken panels. Replacement fasteners will be similar to those recommended by the manufacturer of the product involved. It is obvious that siding material should match that existing in the building. Cleaning of translucent siding is paramount because it is used for lighting and decoration. Choice of detergents and chemical cleaning solutions must be within limitations of the manufacturer's recommendations, or severe damage may result.

4.5.5 Solid Vinyl Siding

Solid vinyl siding is a pigmented polyvinychloride compound, extruded into 0.035-inch-thick shapes and is available in both vertical and horizontal patterns. The material is highly durable and available with long-term guarantees for useful appearance life.

4.5.5.1 *Maintenance.* Painting is usually not required until after 20 years of installed life. The surface is easily cleaned with a mild detergent and water.

4.5.5.2 *Repair.* Damage to the panels is not normally anticipated, but should it occur the manufacturer's recommendation for replacement should be followed. This requires use of the manufacturer's special tool to disengage the panel at the top or end of the panel where it overlaps a flashing. Disengage the top of the damaged panel using the tool to disengage the locks. Remove the nails at the top of the damaged panel, and remove it. Install the replacement by hooking it into the top lock of the panel immediately below the repair and nail the top of the panel into place. Use the manufacturer's tool to lock the panel above the repair into the top lock of the replacement panel by slipping the tool across the top of the replacement panel.

SECTION VI—EXTERIOR INSULATING SYSTEM

4.6.1 General

A variety of exterior insulating systems have been recently developed and used in new construction or added to existing structures. These systems employ a layering of insulation board, reinforcing fabric, synthetic plaster, or copolymer adhesive and synthetic plaster or copolymer finish. Most can be installed directly onto masonry, concrete, metal and wood frame structures. Most products are relatively maintenance-free; however, they are susceptible to damage. Repair and maintenance information for two types of commercial products is as follows.

4.6.2 Dryvit

4.6.2.1 *Maintenance.* No routine maintenance is required. Under normal conditions there should not be any cracking or peeling. The surface may be washed with detergent or painted with an exterior latex paint if a color change is desired.

4.6.2.2 *Repairs.* Repairs should be attempted only when the ambient temperature is above 40°F (4.5°C) and rising, and has been at least 40°F or above for at least 24 hours. The manufacturer's recommended repair procedure for heavily damaged areas is as follows:

a. Using a disk grinder, expose the smooth base-coat Primus layer approximately 2 to 3 inches all around damaged area. Use an aluminum oxide disk of No.48 grit.

b. Cut all components of the Dryvit system out of the damaged area. This includes the finish coat, the base coat, the reinforcing fabric, and the insulation board. Clean the exposed substrate of any old Primus adhesive. Cut a piece of Dryvit insulation board to fit neat and snug and rasp for precise fit. Apply Dryvit mixed Primus adhesive fully over the back of the Dryvit insulation board to a thickness of about **d** inch.

c. Apply the Dryvit insulation board to the substrate. Cut Dryvit reinforcing fabric so that it will cover patch area lapping on to exposed base-coat layer.

d. Apply Primus adhesive mix to the face of the insulation board. With a margin trowel, embed Dryvit reinforcing fabric into the mixed Primus adhesive. The reinforcing fabric should be covered with Primus adhesive to produce a uniform base-coat surface.

e. Using masking tape, mask off the area exposing approximately ¼ inch of the existing finish. After approximately 24 hours, the finish coat can be applied.

f. Trowel on a new finish coat over the new and existing base coat.

g. Allow the Dryvit finish to set up for approximately 10 minutes, depending on weather conditions. Remove tape from the wall.

h. Feather edges of patch to blend inconspicuously with texture of surrounding areas. After patch has dried there will be a slight color variation between the patch and the surrounding area. This should become less conspicuous in the time as environmental conditions blend the color of the patch to the surrounding area. In order to be sure of proper color, Dryvit finish should be matched to the original batch number of the exiting Dryvit finish. Where the Dryvit insulation board is not heavily damaged, it does not have to be replaced.

4.6.3 Sto

4.6.3.1 *Maintenance.* No routine maintenance is required. The finish is permanent, colorfast, and scrubbable.

4.6.3.2 *Repair*. The manufacturer lists the following repair procedures for puncture, damaged corners, and patching finishes. The minimum ambient temperature is 38°F (3.4°C) for at least 12 hours. It is easier to repair a large area than a small one. Make patch large enough to work with.

a. Scrape off the Sto finish from the wall approximately 2 inches around the damaged area. Be careful not to damage the ground coat and mesh in this area.

b. Carefully cut the Sto reinforcing fiberglass mesh to approximately 1 inch from the outer perimeter of the existing finish.

c. Remove the damaged area by cutting out a plug around the puncture leaving a strip of good polystyrene between the mesh and the damaged area.

d. Scrape any remaining adhesive off the face of the substrate.

e. Cut a piece of polystyrene to fit the opening in the system. Make sure the fit is precise to avoid any thermal breaks.

f. Rasp plug to match thickness of existing polystyrene if needed before applying to substrate.

g. Apply adhesive to the back of the polystyrene and put in place with firm pressure making sure the plug is adhered to the substrate.

h. Cut a piece of mesh to butt existing mesh. Apply reinforced plaster over area where mesh is to be placed.

i. Embed mesh in reinforced plaster, keeping same thickness of existing ground coat. Allow reinforced plaster to dry before applying finish.

j. After reinforced plaster has set, prepare area to receive finish. Using masking tape, cover existing finish around patched area.

k. Apply finish and float out to match texture of wall.

l. Remove masking tape and use paintbrush to blend wet finish into the dry finish.

m. In repairing corners, the polystyrene must be replaced back far enough on the wall to allow proper adhesion of polystyrene used to replace damaged area. Make sure corner is double wrapped with Sto reinforced fiber mesh at least 2½ inches.

n. To repair patching finish only, scrape off the Ste finish approximately 1 inch around the damaged area. Using masking tape, cover existing finish around patched area. Apply finish and float out to match texture of wall. Remove masking tape and using a paintbrush, blend wet finish into dry finish.